ENGINEERING CASE LIBRARY

ECL-176A

MECHANICAL HAYHOOK DESIGN

A prototype baled hay hauler included translating individual bales from one position in the hauler to another. The case documents the design of a means to mechanically grasp the bales during the translation.

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MECHANICAL HAYHOOK DESIGN (A)

The Problem

Agriculture, and especially agricultural machinery, has always been of interest to me. During my high school and college years, I spent considerable time and energy helping ranchers haul their baled hay. I am intimately acquainted with the problems of baled hay transportation.

After wrestling with the problem verbally for several years, a rancher who is even more closely acquainted with the problems of baled hay handling and the associated sore muscles and I decided to design a device which hauls baled hay from the field to the storage location. There are hay haulers on the market which are designed primarily for large operations. Our design was aimed at the small rancher who would produce and use his own hay and as a result would wish to load as well as unload the bales individually. The hauler which we designed, built and tested was a full sized prototype model which we used to investigate several aspects of the design. Was it technically sound as well as useful? Although the design of the individual elements was not influenced by manufacturability, the prototype was used to indicate how a production model might be manufactured and the problems which might be encountered. What would be the cost of a production model?

A portion of the hauler we designed included mechanically holding individual bales and translating them from one position in the hauler to another. The position to which the bales are translated was variable so that a fixed conveyor-like device was not appropriate. The particular design problem which I will discuss here is the device which attached to a bale for the purpose of moving it from one location to another. The justification of this device and how it is caused to move from one location to the other will not be discussed.

Your Design

Before reading further about my solution to this problem, it might be interesting to design your own means of attachment to a bale of hay.

A typical bale is shown in Figure 1. After baling, the bales rest on the ground in the position shown in Figure 1. This position eliminates contact between the ground and the wire or twine which lengthens its life. In the hauling device we designed, the bale is only caused to translate so the wire or twine always remains on the sides of the bales. The texture of a bale of hay can be quite variable ranging from a very loose bale, into which you can force your fingers up to the knuckles, to a very tightly packed bale where it is hard to make any kind of penetration into the hay with your fingers. A sharp, slender object will go into all bales of hay but the force required varies with the texture and compactness of the bale.

For my design I considered function as primary since I was designing a prototype model, but manufacturability and cost were also considered when studying alternatives.

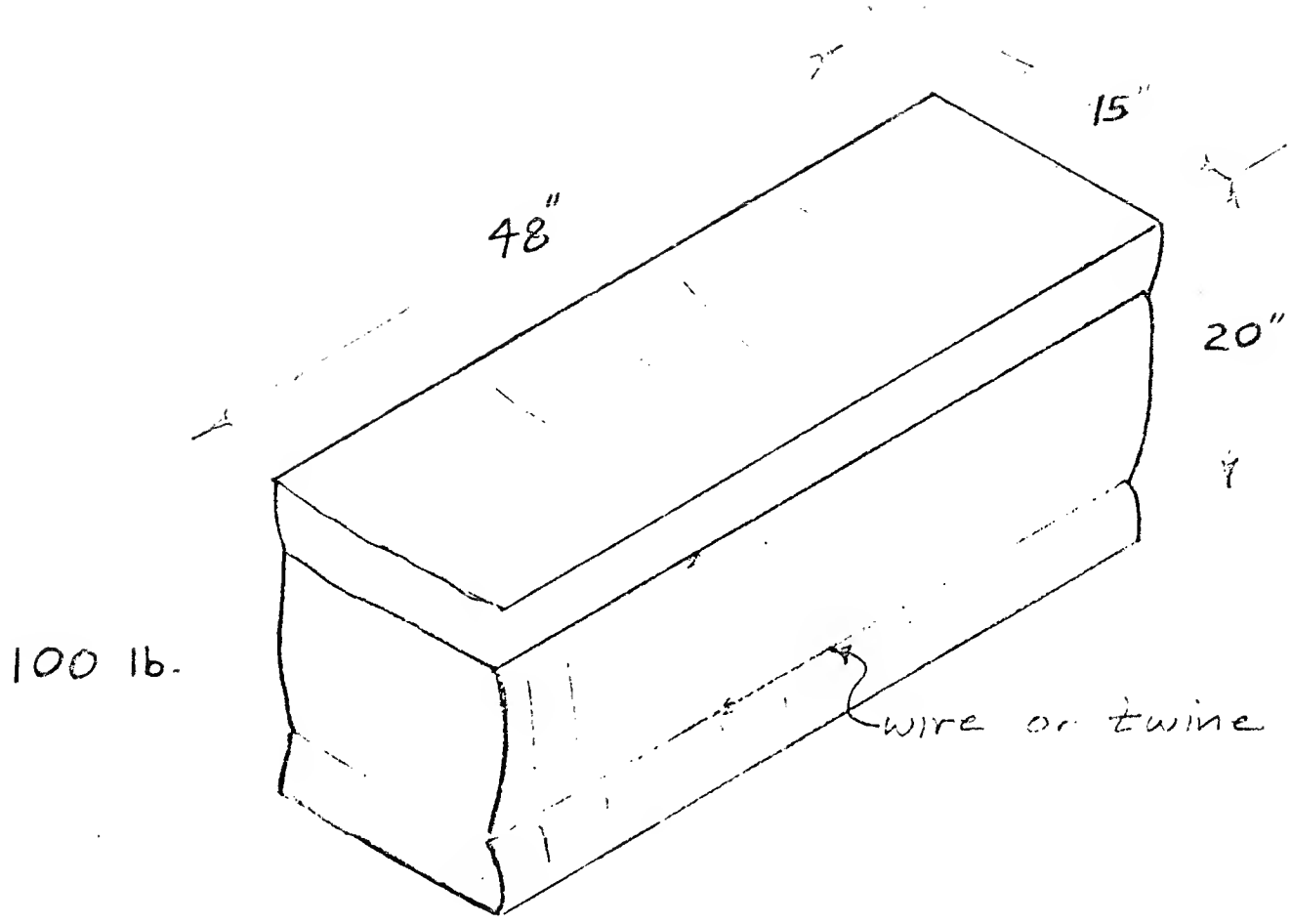

Figure 1 - Typical Bale of Hay

MECHANICAL HAYHOOK DESIGN (B)

The Design

Here is a chronological description of how I designed a device to attach to a bale of hay.

When one designs a device which replaces an activity that he normally does by hand, it is hard, at least I find it so, to divorce himself from considering how his hands can be directly replaced mechanically. Hay is normally handled by hand with the aid of large hooks which are held one in each hand and attached to the bale of hay by a simple swinging action. The hook can then be removed by a rotation which is easy to accomplish since the hook becomes polished and slips very easily from the fiberous hay. Figure 2 illustrates how hayhooks are used.

I was consciously influenced by hand handling of hay as I initially established alternate approaches. A single hook, opposing hooks similar to a clam shell, and mechanical jaws which gripped the entire bale were considered. The single hook was chosen because of its mechanical simplicity and size.

Figure 3 shows the first hook that was constructed and tried. A frame was positioned on the bale of hay. The shaft which was attached to this frame was hydraulically caused to rotate, thus, driving the circular hook into the hay. The hook was flame cut from a 1/4 inch steel plate and welded to a circular collar which was keyed to the driving shaft. Since the hook was one of many items being designed for the hay hauler, more attention was given to the ease of making the prototype hook then to its actual detailed operation.

This initial design had several problems. The primary one was that the cross-sectional shape of the hook was so large that it was practically impossible to drive it into an average density bale. The hook also had very little lateral support and consequently became bent very easily.

I decided that a circular and thinner curved portion of the hook would be beneficial and so tried a second design which is shown in Figure 4. The curved portion of the hook made from 1/4 inch plate was removed and a sharpened cold rolled rod added.

I did not expect that this would be the final design but I tried it because it was easy to build and would give the answer to the question then being asked, "Will the round cross-section work?"

The round cross-section did work very nicely. The round curved hook was easy to drive into the bale but had no strength because the rod near the weld had little resistance to moment. Heat from the weld has softened the metal. Another potential problem of this design was its repairability. That is, it wouldn't be very easy to replace the hook if it were damaged in the field.

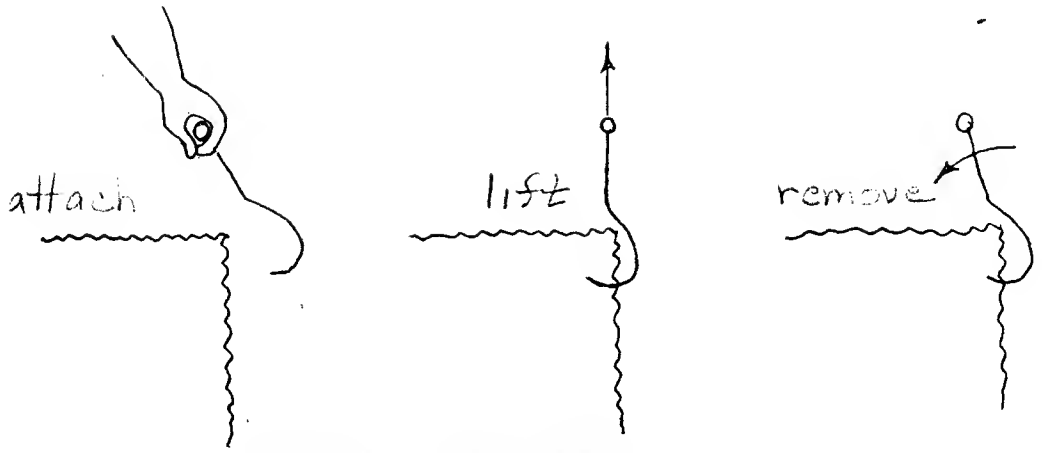

Figure 2 - Hand Held Hay Hook

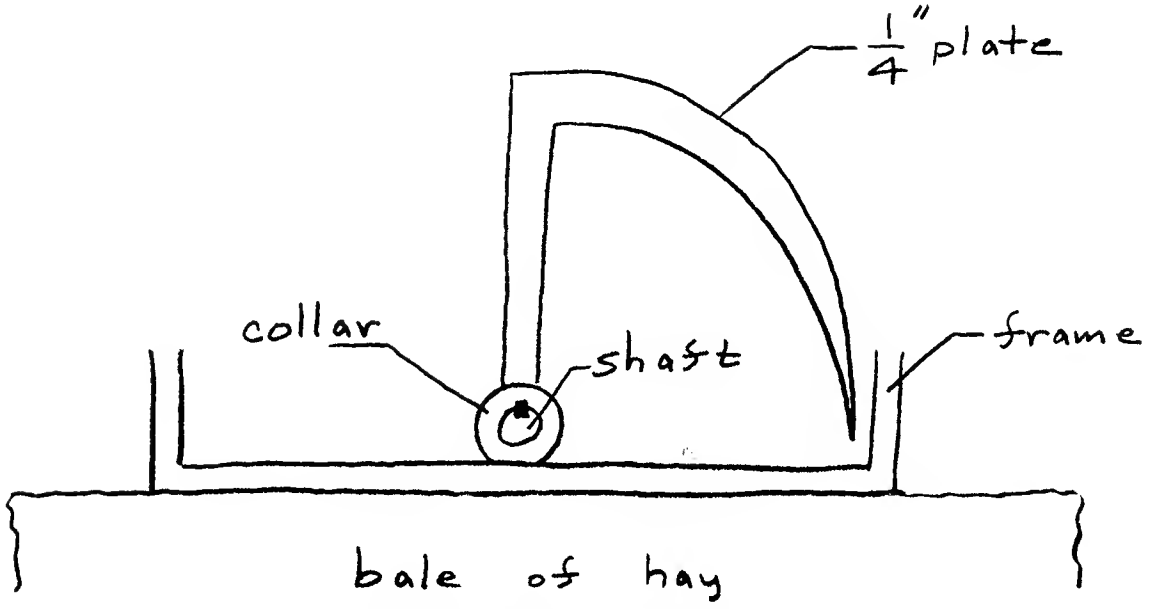

Figure 3 - Initial Design

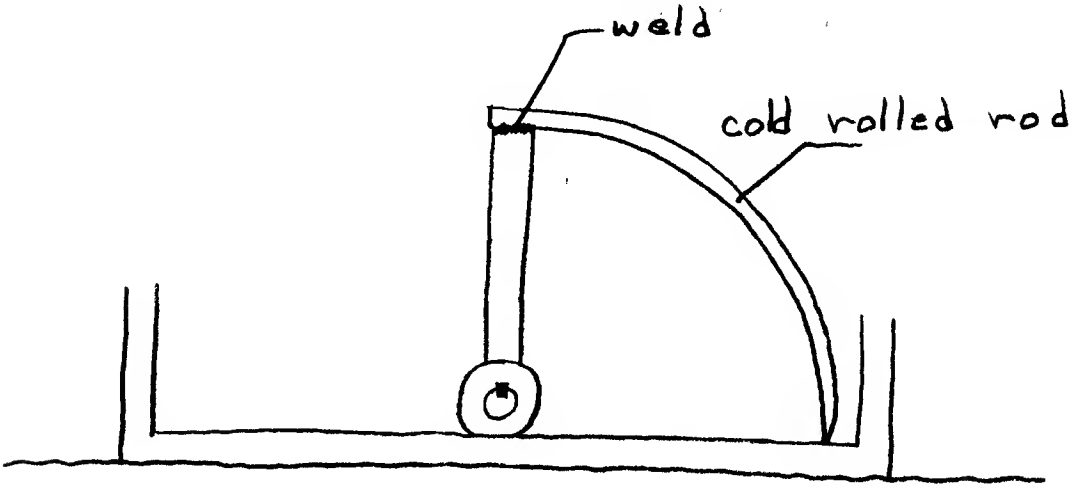

Figure 4 - Second Design

With the benefit of the first two designs I tried a third design which is shown in Figure 5, which at the time I considered to be the final design. The hook was made of spring steel which was rolled into shape and then stress relieved. This hook was mounted on a pie shaped plate and mechanically held with the cap and the strap. The cap locates the hook and transmits thrust to it and the strap holds the hook to the plate and can be removed for easy replacement of the spring steel hook.

The third design also had some problems. The strap which held the hook to the plate loosened up and was not at all satisfactory. The hook was easily driven into most bales, but when the bale was lifted it tended to slip off the hook because of the slope of the hook and the small coefficient of friction between the hook and the hay. I also found that for dense hay the driving system didn't have enough power to drive the hook into the bale. Further, with very loose hay, in addition to slipping, the single hook tended to pull out of the hay.

Now with the benefit of three designs a fourth and final design was developed and found to be quite satisfactory. It is shown in Figure 6. The spring steel hook was fastened to the plate with set screws and two such assemblies per bale were used in parallel instead of one, eliminating the pull-out problem. To eliminate the bales from slipping off the hooks; one immediately thinks of opposing hooks, that is, a second set acting in the opposite direction as the first. This doubles the mechanical complexity. I decided to add a straight tooth which is attached to the frame with a set screw and a collar as shown in Figure 6. As the frame is placed on the bale, the straight tooth is driven into the bale and prevents the bale from moving horizontally when it is lifted. This solution worked quite satisfactorily and did not increase the mechanical complexity of the hook assembly. The power requirement problem mentioned previously was taken care of by simply increasing the moment arm of the hydraulic cylinder causing the shaft rotation.

The final design did have the three characteristics that I originally sought. It was very functional both from an operational and a maintenance point of view; could be relatively easily manufactured; and it was mechanically simple and consequently relatively inexpensive.

Epilog

It is interesting to note that the final design looks very similar to what one does manually. The straight hook is analogous to one's knee on the end of the bale, and the curved hooks act as those held by one's hands, or the straight and curved hooks could be thought of as opposing hand held hooks.

Were the three iterations I went through to arrive at the final design necessary? Was I overly influenced by my past experience of hand handling baled hay? How does your design compare with mine?

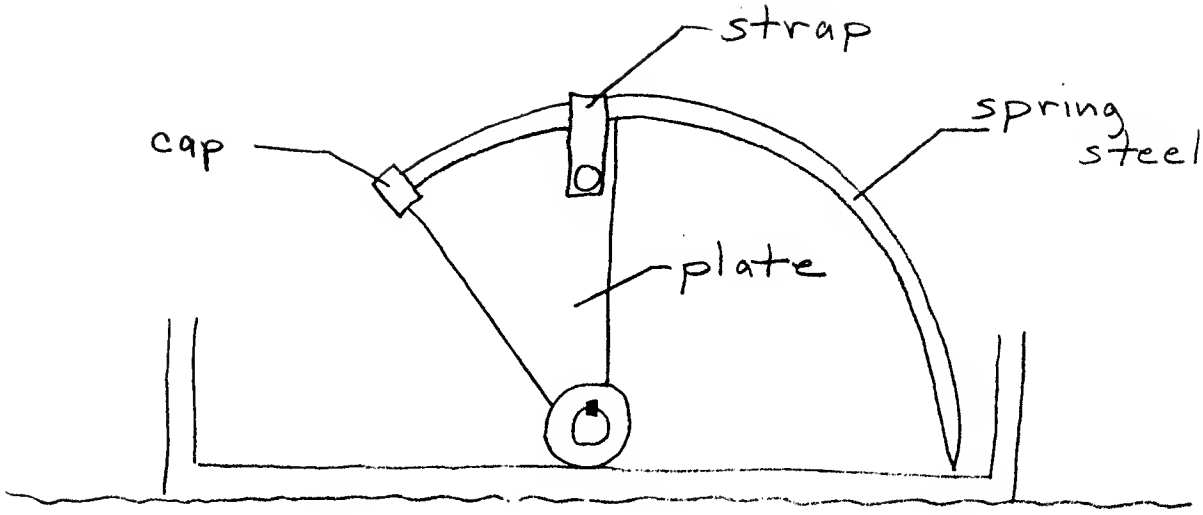

Figure 5 - Third Design

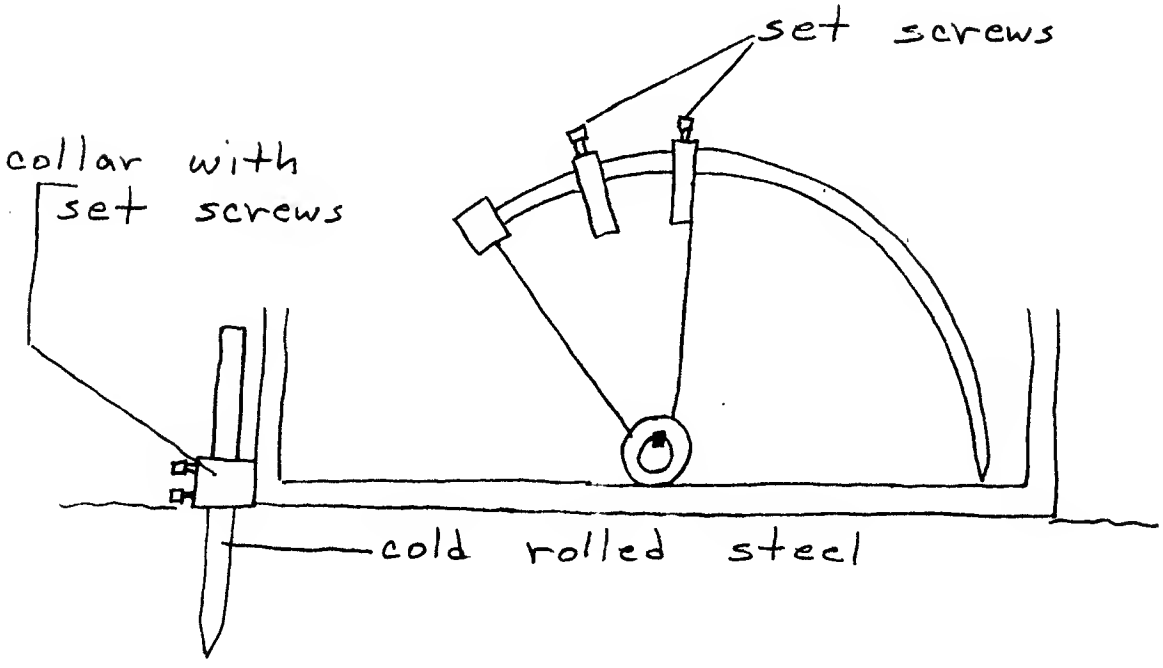

Figure 6 - Final Design